

CW 3GeV Linac Error Simulations at 10 mA

v.3.8.3

Error Studies with TRACKv39

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New CW lattice received 07-Jan-2011

- ▶ New CW Lattice received 07-JAN-2011 from AV
- ▶ 16000 jobs sent on FermiGrid to study behaviour of this lattice w.r.t errors and jitter

ALIGN/ALGN2 Parameter TRACKv39

- **ALIGN** name δ_{xy} δ_z ϕ_z $\delta\phi_{dyn.}$ $\delta F_{dyn.}$ $\delta\phi_{static}$ δF_{static}
- **ALGN2** name δ_x δ_y δ_z ϕ_x ϕ_y ϕ_z $\delta\phi_{dyn.}$ $\delta F_{dyn.}$ $\delta\phi_{static}$ δF_{static}

- ▶ $\delta_{xy} [cm]$ From the max allowed displacement of element ends, the maximum allowed rotation is calculated. Then the random errors are generated for both displacement and rotation. The generated errors are accepted only if the final displacements of the element ends is within the tolerance (max allowed displacement) specified as input. Uniform distribution.
- ▶ $\delta_x [cm]$ Displacement parallel to the x-axis. Uniform distribution.
- ▶ $\phi_x [mrad]$ Rotation of the element with respect to the center of the element. Uniform distribution
- ▶ $\delta\phi_{dyn.} [deg]$: Amplitude of the dynamic phase error of the device. Gaussian distribution truncated at 3 sigma.
- ▶ $\delta F_{dyn.} [\%]$: Amplitude of the dynamic field error of the device. Gaussian distribution truncated at 3 sigma.
- ▶ $\delta\phi_{static} [deg]$: Amplitude of the static phase error of the device. Uniform distribution.
- ▶ $\delta F_{static} [\%]$: Amplitude of the static field error of the device.

Error Simulation (16000 runs)

- ▶ From RFQ exit to end of the CW 3 GeV linac (\sim 418 meters)
- ▶ 40 errors simulated with TRACKv39
- ▶ Each error simulated with 400 seeds with 3D SC (10 mA) and 50k per seed
- ▶ $40 \times 400 = 16000$ runs with TRACKv39 on FermiGrid

Parameters 01-20

- ▶ 01/ Solenoids $\delta_x = 150 \mu\text{m}$
- ▶ 02/ Solenoids $\delta_x = 300 \mu\text{m}$
- ▶ 03/ Solenoids $\delta_x = 500 \mu\text{m}$
- ▶ 04/ Solenoids $\delta_x = 750 \mu\text{m}$
- ▶ 05/ Solenoids $\delta_x = 1000 \mu\text{m}$

- ▶ 06/ Solenoids $\phi_x = 1 \text{ mrad}$
- ▶ 07/ Solenoids $\phi_x = 2 \text{ mrad}$
- ▶ 08/ Solenoids $\phi_x = 3 \text{ mrad}$
- ▶ 09/ Solenoids $\phi_x = 4 \text{ mrad}$
- ▶ 10/ Solenoids $\phi_x = 5 \text{ mrad}$

- ▶ 11/ Solenoids $\delta_{xy} = 150 \mu\text{m}$
- ▶ 12/ Solenoids $\delta_{xy} = 300 \mu\text{m}$
- ▶ 13/ Solenoids $\delta_{xy} = 500 \mu\text{m}$
- ▶ 14/ Solenoids $\delta_{xy} = 750 \mu\text{m}$
- ▶ 15/ Solenoids $\delta_{xy} = 1000 \mu\text{m}$

- ▶ 16/ Quads $\delta_x = 150 \mu\text{m}$
- ▶ 17/ Quads $\delta_x = 300 \mu\text{m}$
- ▶ 18/ Quads $\delta_x = 500 \mu\text{m}$
- ▶ 19/ Quads $\delta_x = 750 \mu\text{m}$
- ▶ 20/ Quads $\delta_x = 1000 \mu\text{m}$

Parameters 21-40

- ▶ 21/ Quads $\delta_{xy} = 150 \mu\text{m}$
- ▶ 22/ Quads $\delta_{xy} = 300 \mu\text{m}$
- ▶ 23/ Quads $\delta_{xy} = 500 \mu\text{m}$
- ▶ 24/ Quads $\delta_{xy} = 750 \mu\text{m}$
- ▶ 25/ Quads $\delta_{xy} = 1000 \mu\text{m}$
- ▶ 26/ Cav. Phase $\delta F_{dyn} = 0.5 \%$
- ▶ 27/ Cav. Phase $\delta F_{dyn} = 1.0 \%$
- ▶ 28/ Cav. Phase $\delta F_{dyn} = 1.5 \%$
- ▶ 29/ Cav. Phase $\delta F_{dyn} = 2.0 \%$
- ▶ 30/ Cav. Phase $\delta F_{dyn} = 2.5 \%$
- ▶ 31/ Cav. Field $\delta\phi_{dyn.} = 0.5^\circ$
- ▶ 32/ Cav. Field $\delta\phi_{dyn.} = 1.0^\circ$
- ▶ 33/ Cav. Field $\delta\phi_{dyn.} = 1.5^\circ$
- ▶ 34/ Cav. Field $\delta\phi_{dyn.} = 2.0^\circ$
- ▶ 35/ Cav. Field $\delta\phi_{dyn.} = 2.5^\circ$
- ▶ 36/ $\delta\phi_{dyn.} = 0.5^\circ$ & $\delta F_{dyn} = 0.5 \%$
- ▶ 37/ $\delta\phi_{dyn.} = 1.0^\circ$ & $\delta F_{dyn} = 1.0 \%$
- ▶ 38/ $\delta\phi_{dyn.} = 1.5^\circ$ & $\delta F_{dyn} = 1.5 \%$
- ▶ 39/ $\delta\phi_{dyn.} = 2.0^\circ$ & $\delta F_{dyn} = 2.0 \%$
- ▶ 40/ $\delta\phi_{dyn.} = 2.5^\circ$ & $\delta F_{dyn} = 2.5 \%$

(001) Solenoids $\delta_x = 150 \mu\text{m}$

Figure: RMS Emittance X

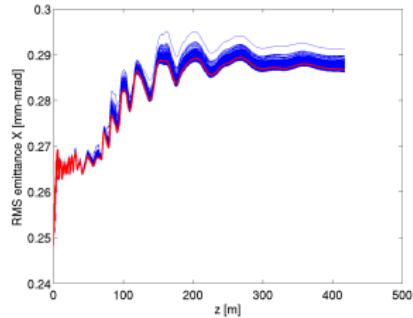


Figure: Centroid X

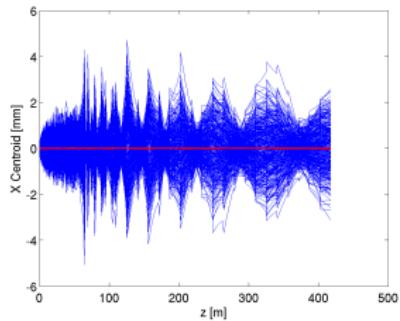


Figure: RMS Emittance Z

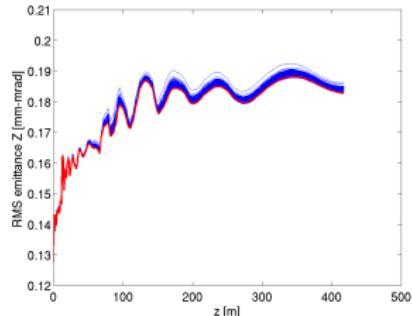
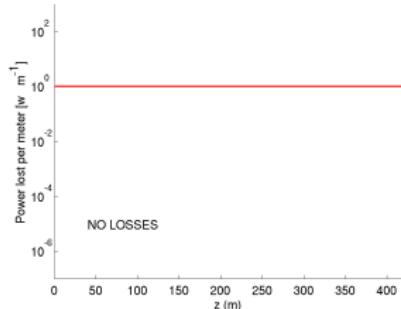


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(002) Solenoids $\delta_x = 300 \mu\text{m}$

Figure: RMS Emittance X

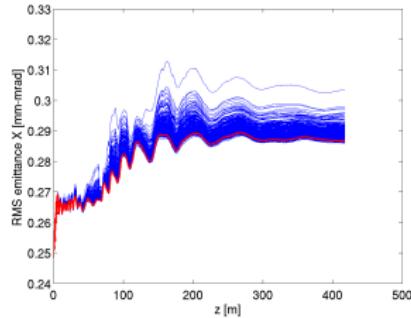


Figure: Centroid X

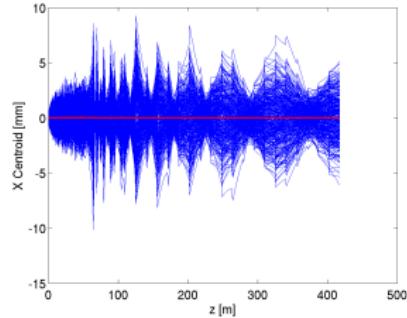


Figure: RMS Emittance Z

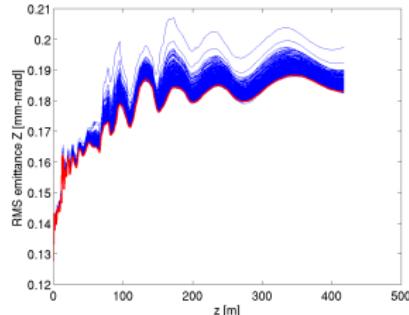
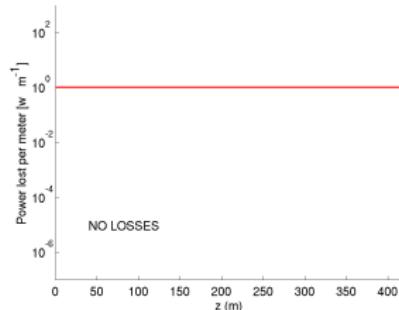


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(003) Solenoids $\delta_x = 500 \mu\text{m}$

Figure: RMS Emittance X

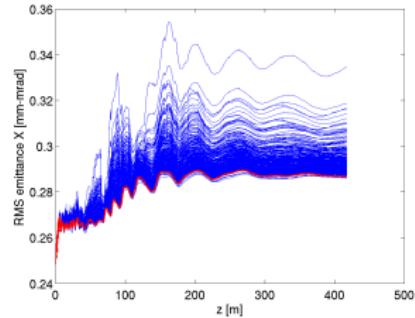


Figure: Centroid X

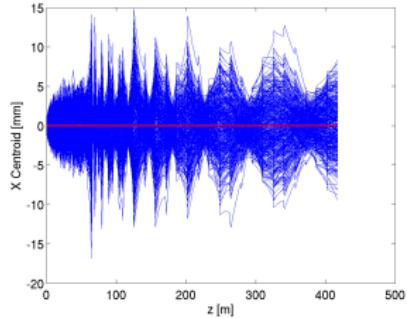


Figure: RMS Emittance Z

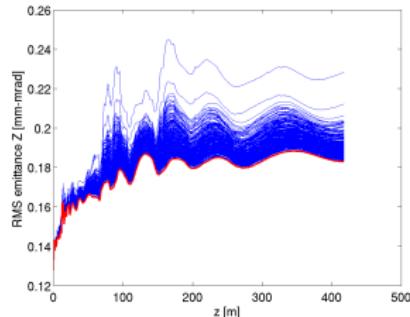
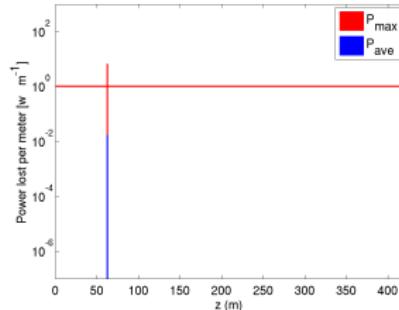


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(004) Solenoids $\delta_x = 750 \mu\text{m}$

Figure: RMS Emittance X

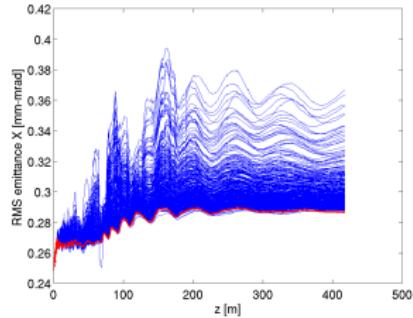


Figure: Centroid X

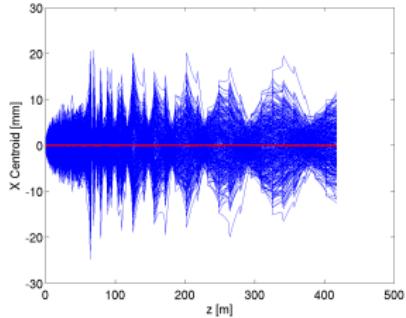


Figure: RMS Emittance Z

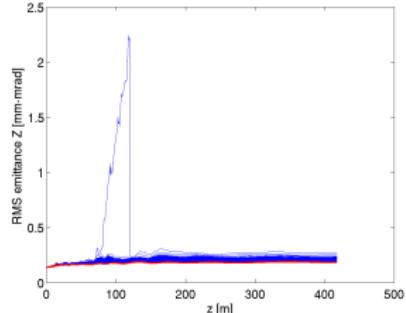
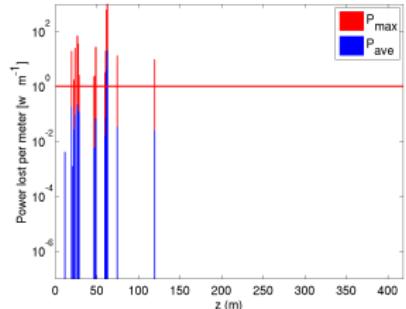


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(005) Solenoids $\delta_x = 1000 \mu\text{m}$

Figure: RMS Emittance X

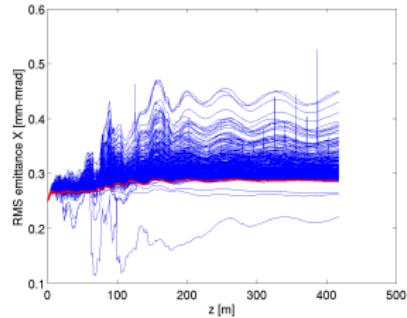


Figure: Centroid X

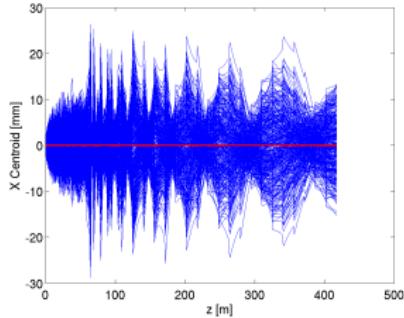


Figure: RMS Emittance Z

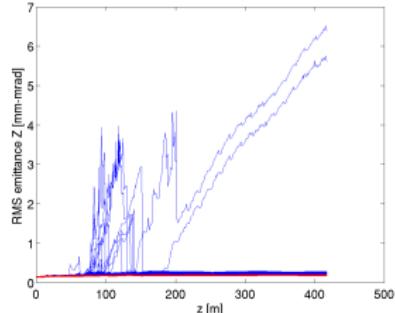
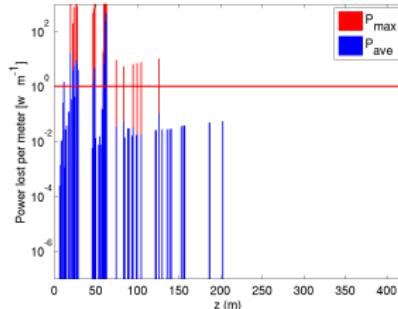


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(006) Solenoids $\phi_x = 1$ mrad

Figure: RMS Emittance X

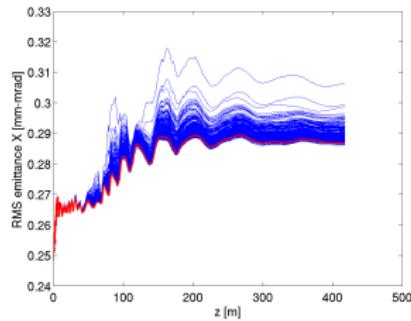


Figure: Centroid X

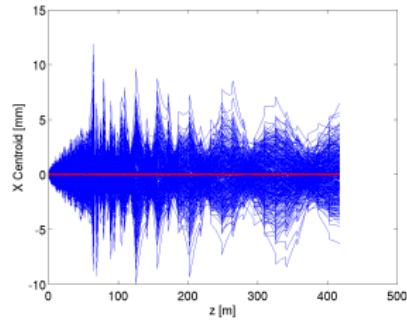


Figure: RMS Emittance Z

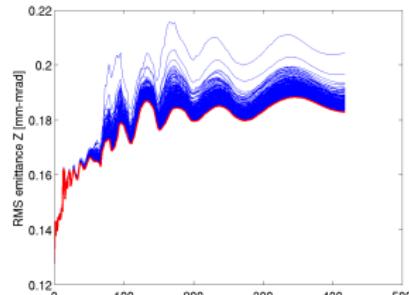


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(007) Solenoids $\phi_x = 2$ mrad

Figure: RMS Emittance X

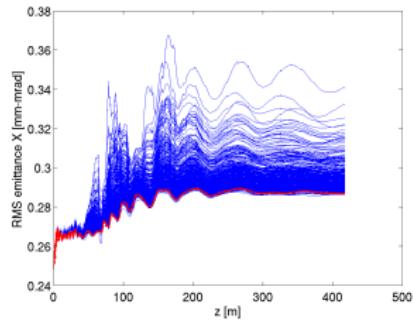


Figure: Centroid X

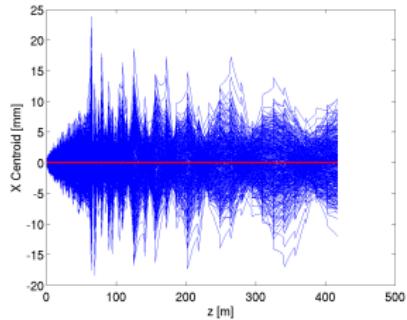


Figure: RMS Emittance z

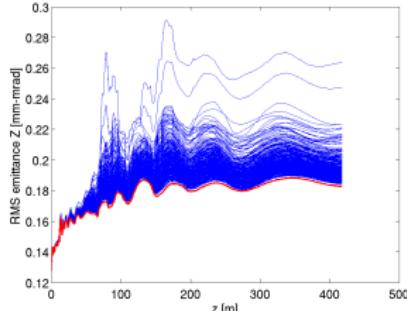
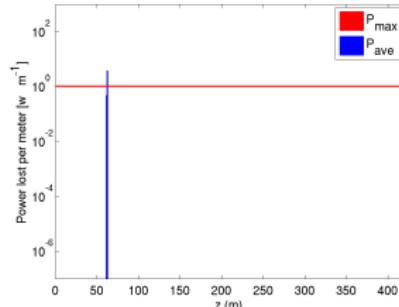


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(008) Solenoids $\phi_x = 3$ mrad

Figure: RMS Emittance X

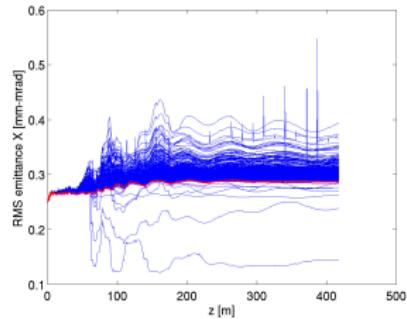


Figure: Centroid X

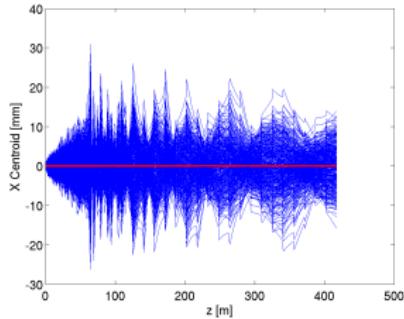


Figure: RMS Emittance Z

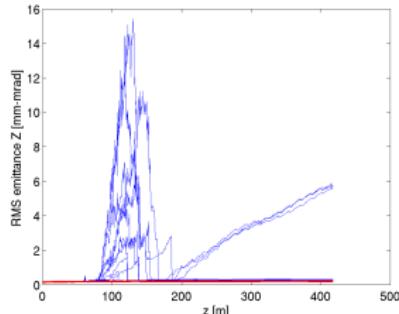
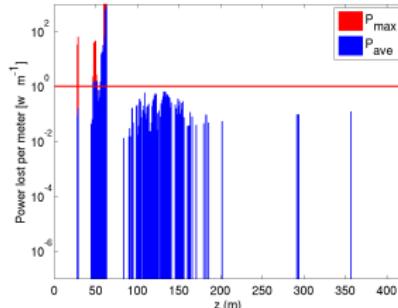


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(009) Solenoids $\phi_x = 4$ mrad

Figure: RMS Emittance X

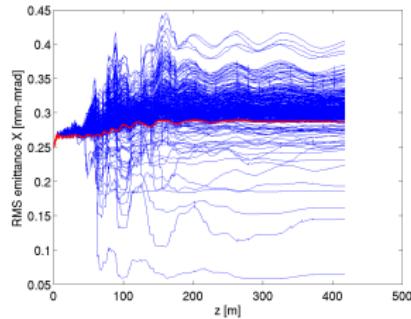


Figure: Centroid X

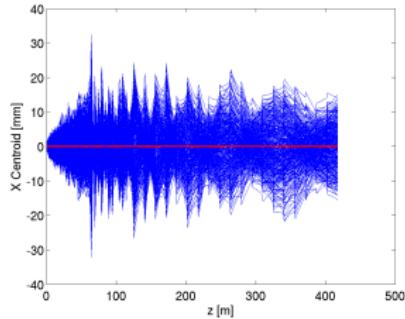


Figure: RMS Emittance Z

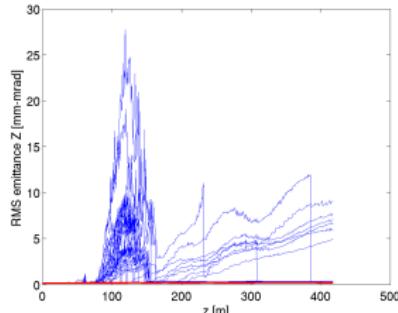
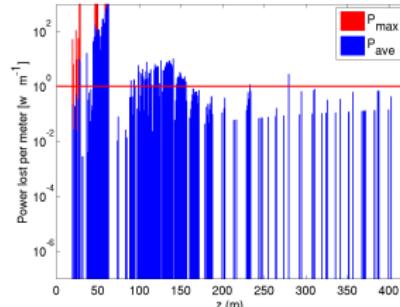


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(010) Solenoids $\phi_x = 5$ mrad

Figure: RMS Emittance X

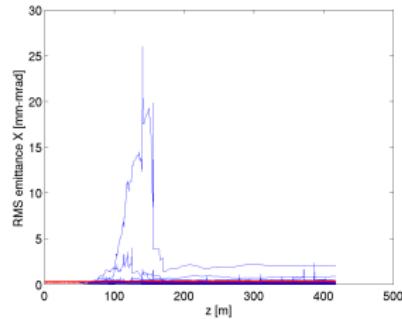


Figure: Centroid X

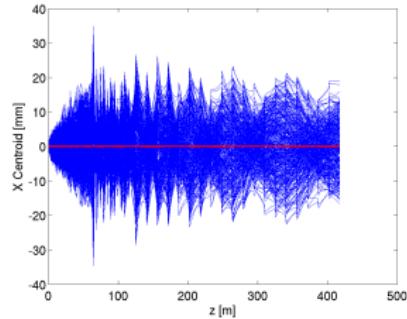


Figure: RMS Emittance Z

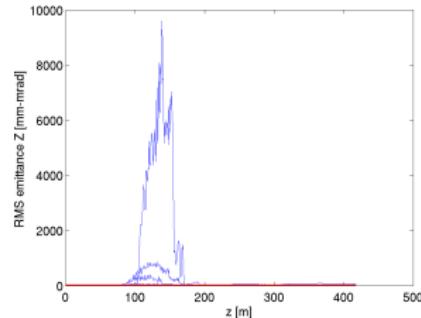
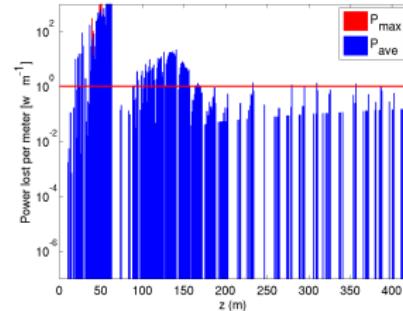


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(011) Solenoids $\delta_{xy} = 150 \mu\text{m}$

Figure: RMS Emittance X

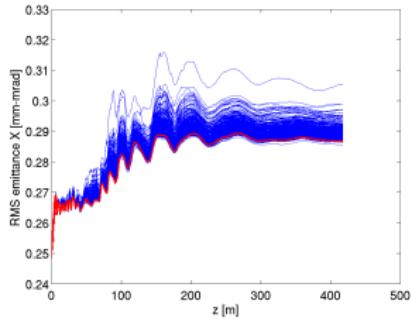


Figure: Centroid X

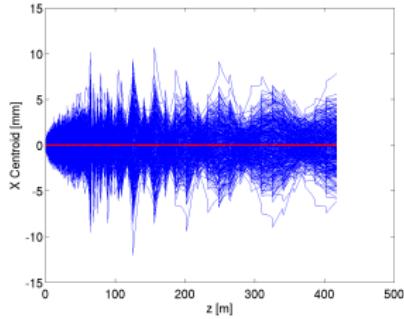


Figure: RMS Emittance Z

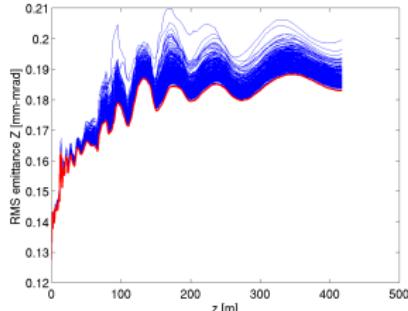
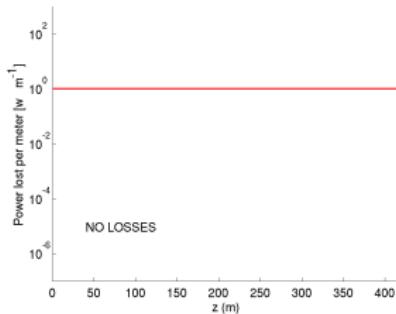


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(012) Solenoids $\delta_{xy} = 300 \mu\text{m}$

Figure: RMS Emittance X

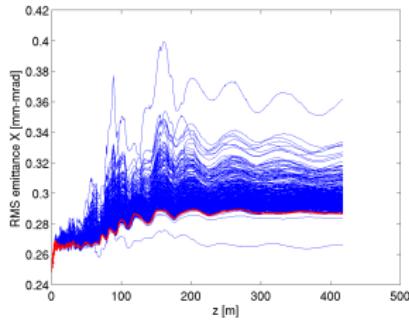


Figure: Centroid X

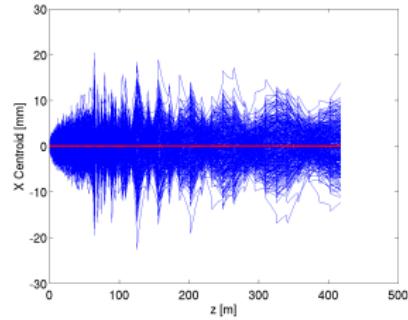


Figure: RMS Emittance Z

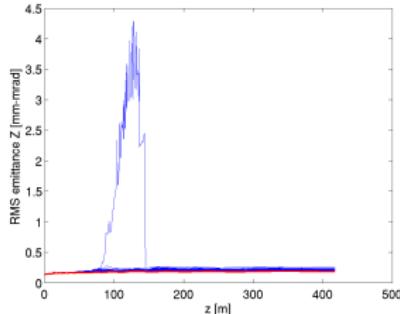
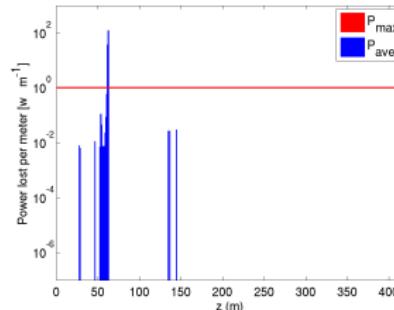


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(013) Solenoids $\delta_{xy} = 500 \mu\text{m}$

Figure: RMS Emittance X

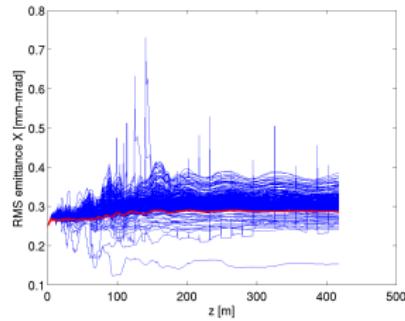


Figure: Centroid X

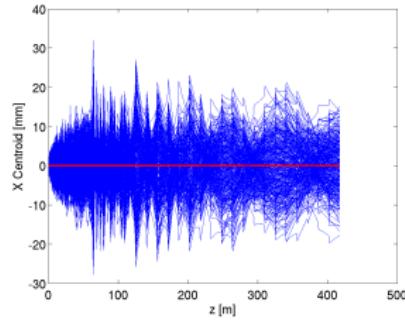


Figure: RMS Emittance Z

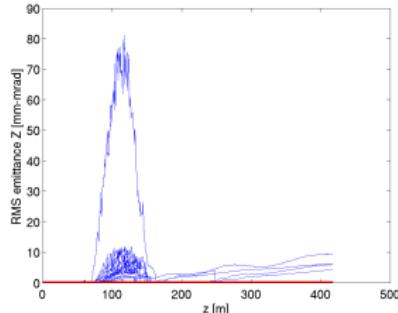
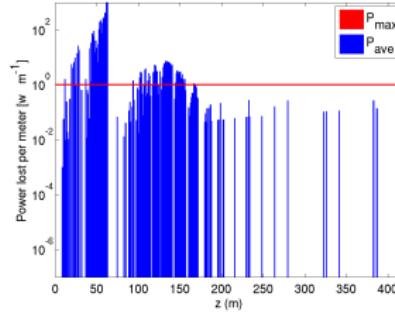


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(014) Solenoids $\delta_{xy} = 750 \mu\text{m}$

Figure: RMS Emittance X

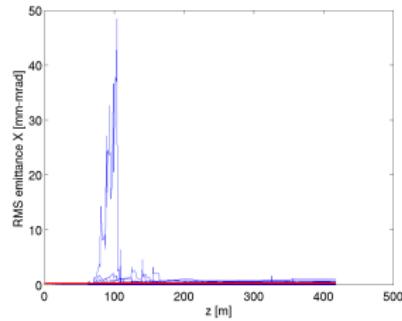


Figure: Centroid X

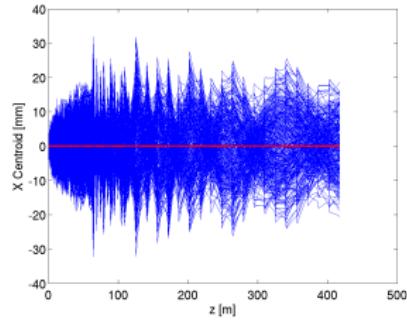


Figure: RMS Emittance Z

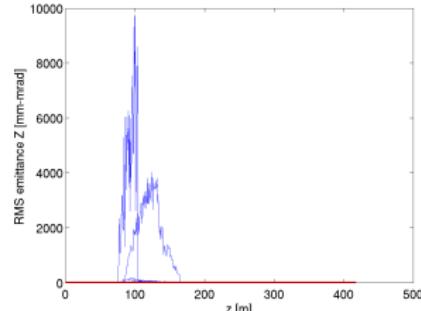
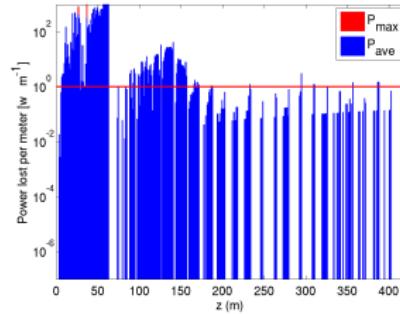


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(015) Solenoids $\delta_{xy} = 1000 \mu\text{m}$

Figure: RMS Emittance X

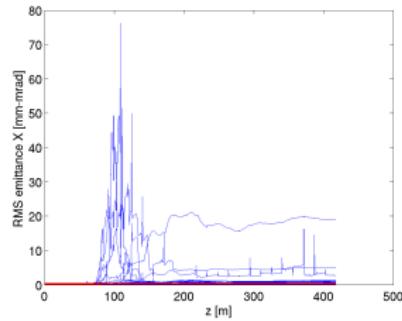


Figure: Centroid X

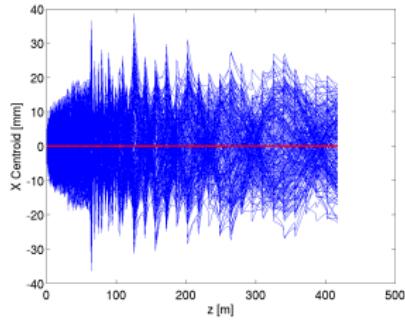


Figure: RMS Emittance Z

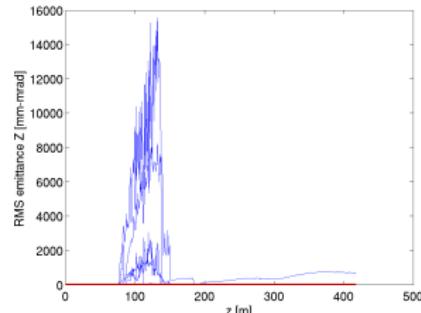
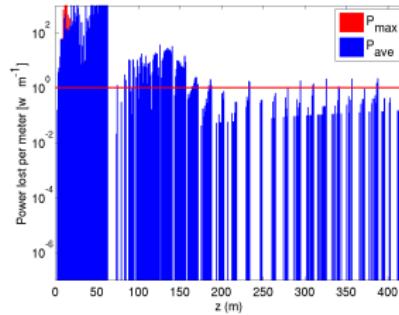


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(016) Quads $\delta_x = 150 \mu\text{m}$

Figure: RMS Emittance X

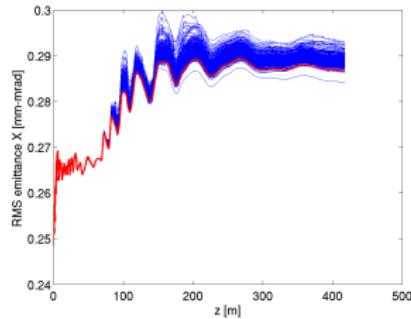


Figure: Centroid X

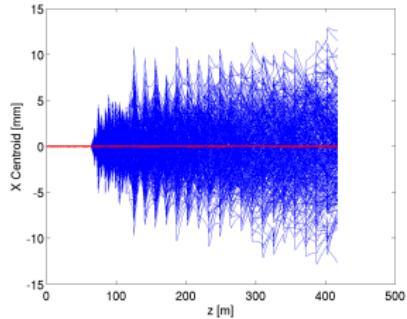


Figure: RMS Emittance Z

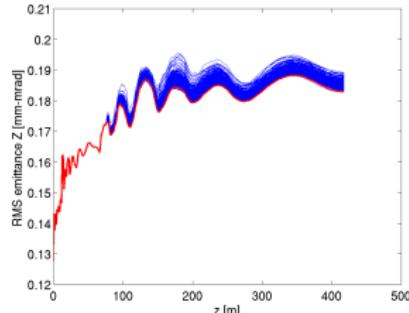
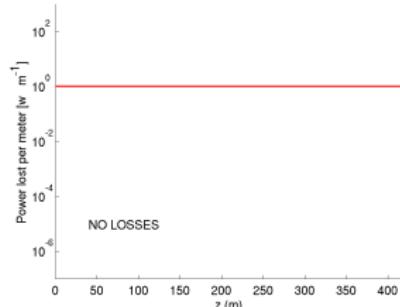


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(017) Quads $\delta_x = 300 \mu\text{m}$

Figure: RMS Emittance X

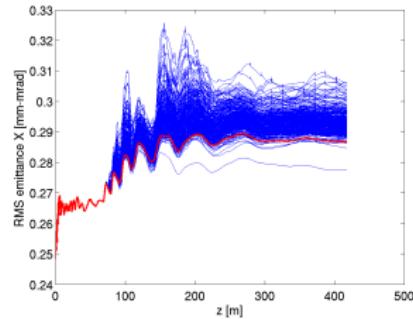


Figure: Centroid X

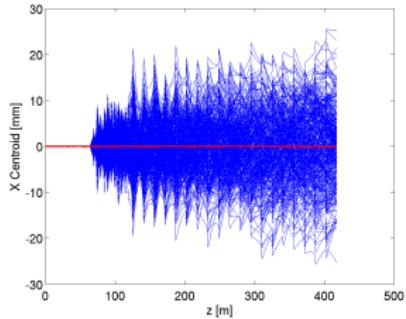


Figure: RMS Emittance z

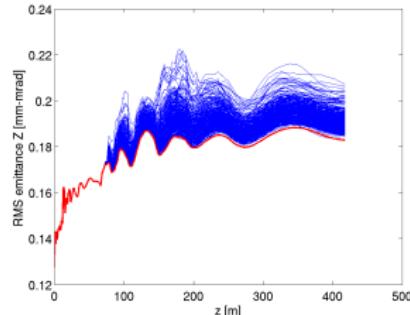
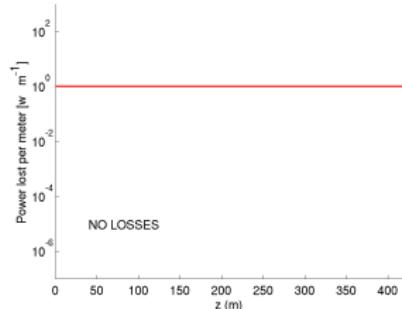


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(018) Quads $\delta_x = 500 \mu\text{m}$

Figure: RMS Emittance X

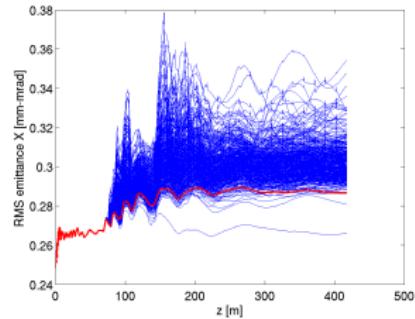


Figure: Centroid X

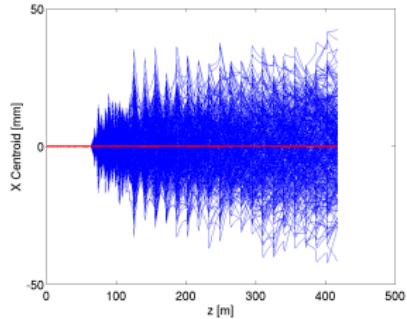


Figure: RMS Emittance Z

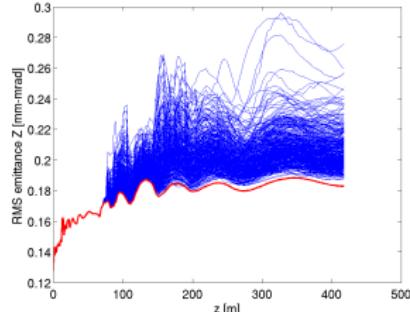
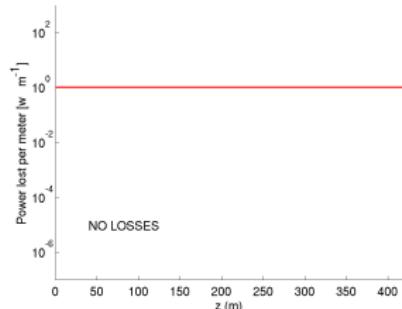


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(019) Quads $\delta_x = 750 \mu\text{m}$

Figure: RMS Emittance X

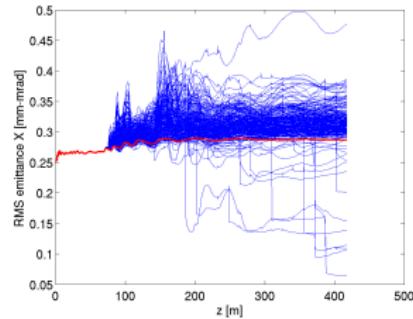


Figure: Centroid X

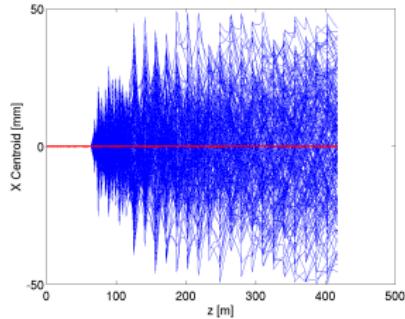


Figure: RMS Emittance Z

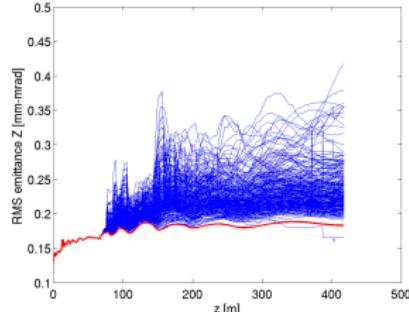
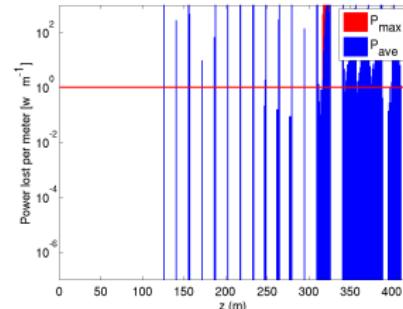


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(020) Quads $\delta_x = 1000 \mu\text{m}$

Figure: RMS Emittance X

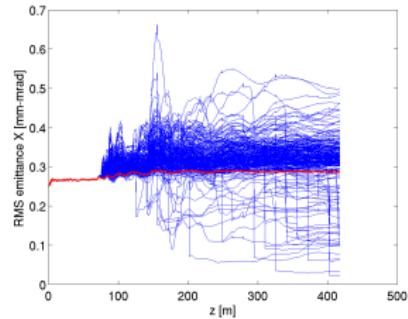


Figure: Centroid X

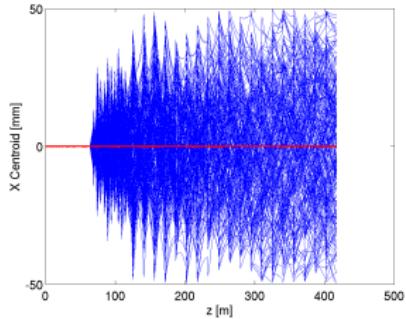


Figure: RMS Emittance Z

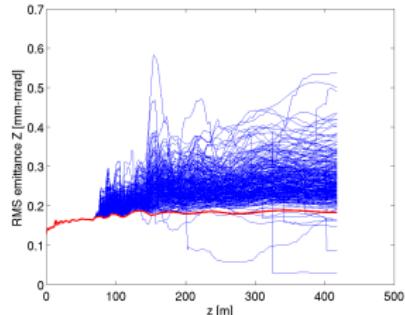
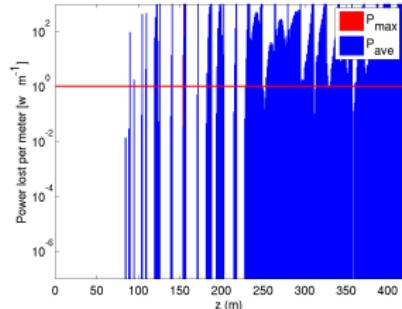


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(021) Quad. $\delta_{xy} = 150 \mu\text{m}$

Figure: RMS Emittance X

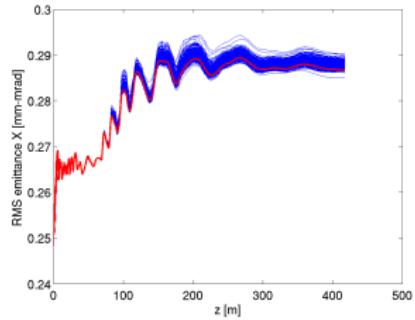


Figure: Centroid X

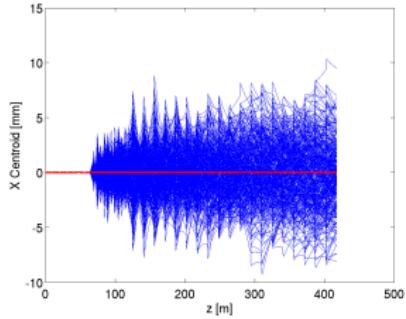


Figure: RMS Emittance Z

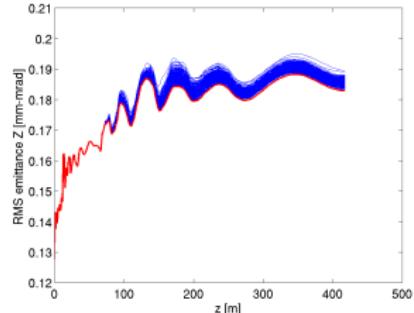
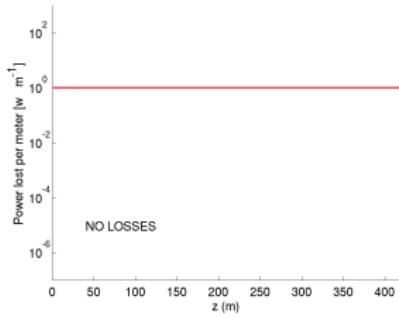


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(022) Quad. $\delta_{xy} = 300 \mu\text{m}$

Figure: RMS Emittance X

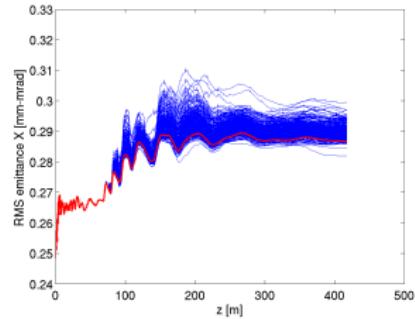


Figure: Centroid X

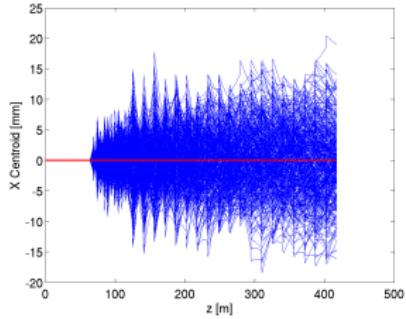


Figure: RMS Emittance Z

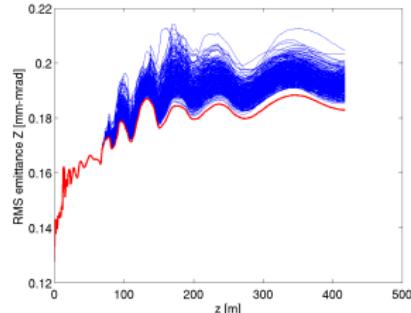
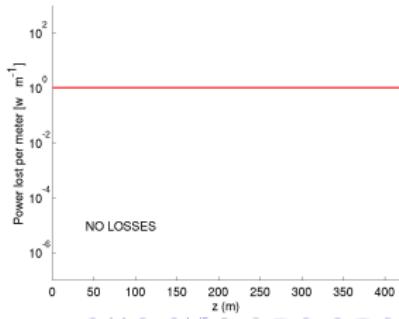


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(023) Quad. $\delta_{xy} = 500 \mu\text{m}$

Figure: RMS Emittance X

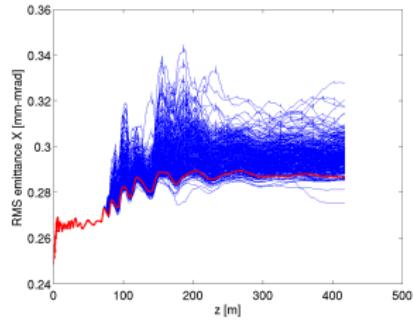


Figure: Centroid X

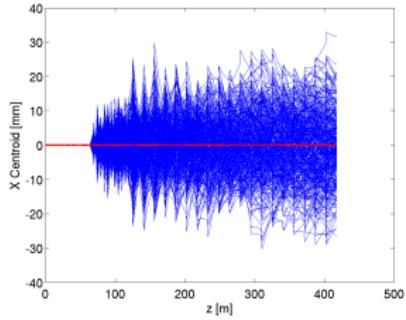


Figure: RMS Emittance Z

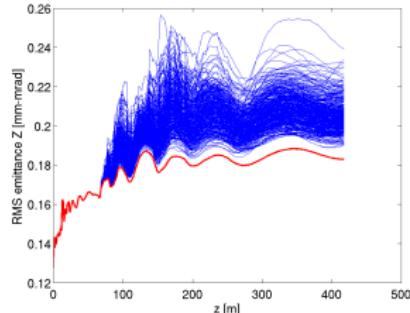
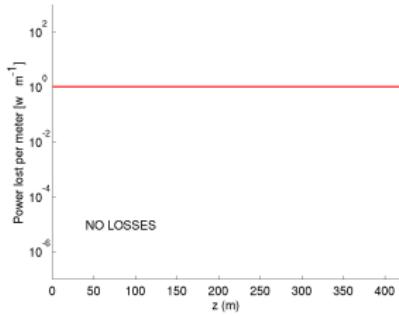


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(024) Quad. $\delta_{xy} = 750 \mu\text{m}$

Figure: RMS Emittance X

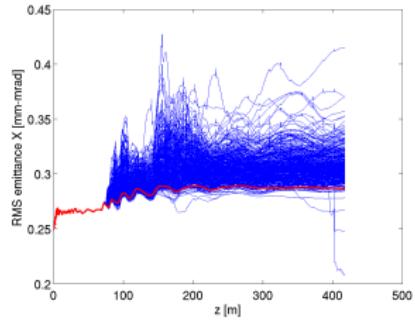


Figure: Centroid X

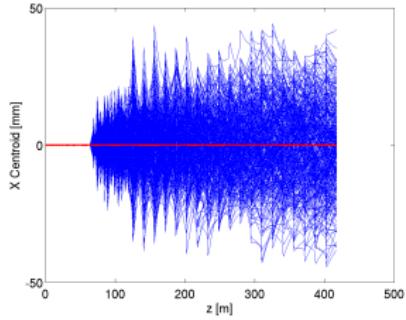


Figure: RMS Emittance Z

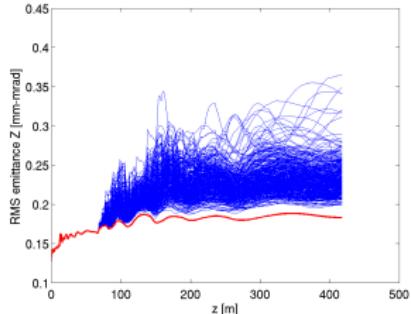
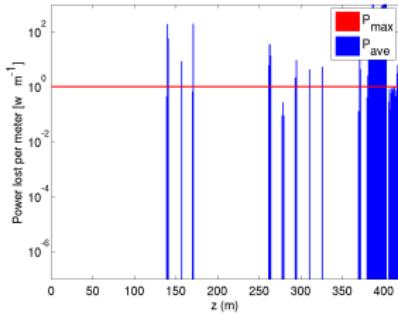


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(025) Quad. $\delta_{xy} = 1000 \mu\text{m}$

Figure: RMS Emittance X

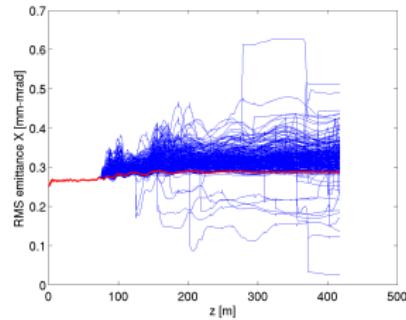


Figure: Centroid X

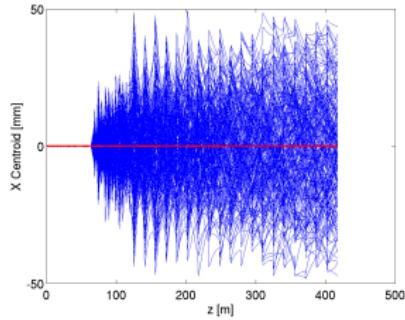


Figure: RMS Emittance Z

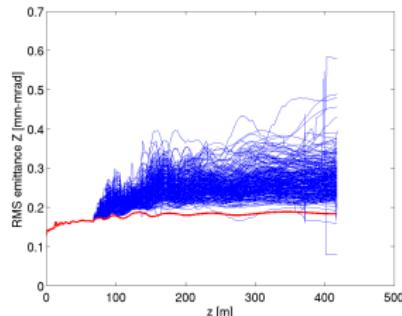
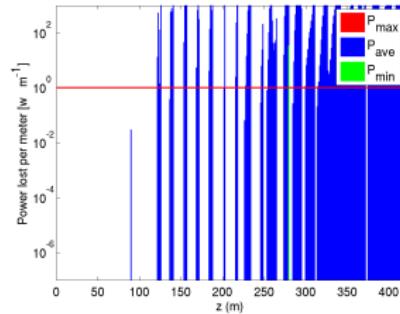


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(026) Cav. Field $\delta\phi_{dyn} = 0.5^\circ$

Figure: RMS Emittance X

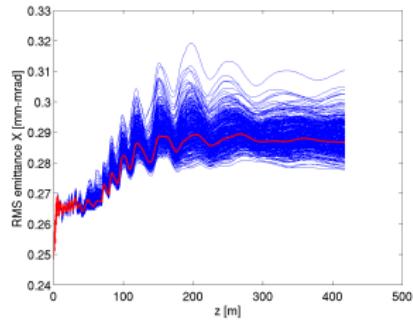


Figure: Centroid Z

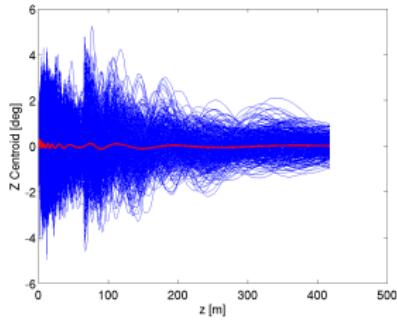


Figure: RMS Emittance Z

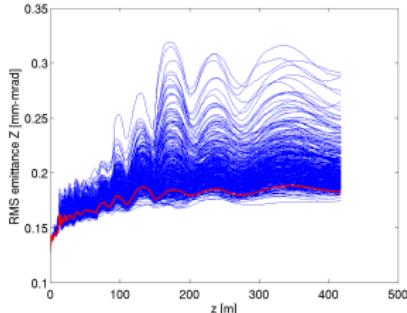
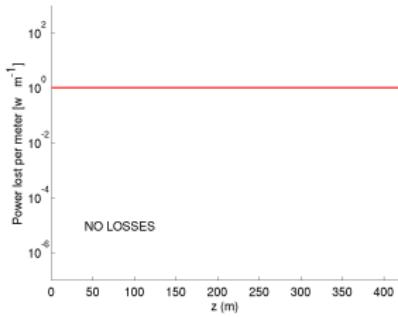


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(027) Cav. Field $\delta\phi_{dyn} = 1.0^\circ$

Figure: RMS Emittance X

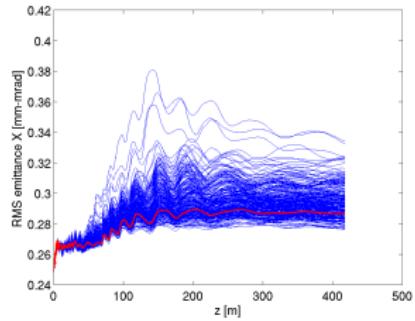


Figure: Centroid Z

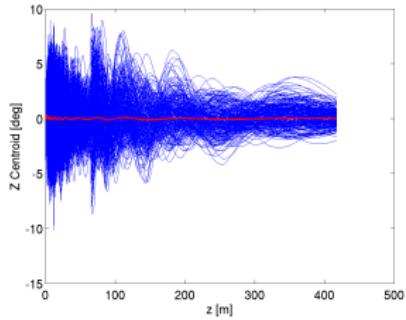


Figure: RMS Emittance z

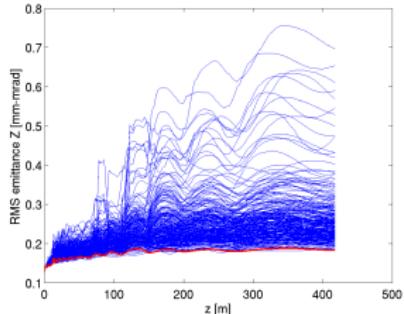
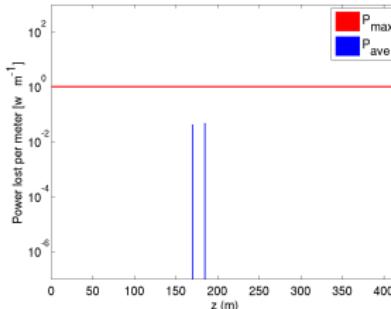


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(028) Cav. Field $\delta\phi_{dyn} = 1.5^\circ$

Figure: RMS Emittance X

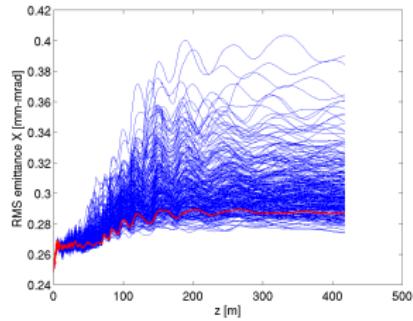


Figure: Centroid Z

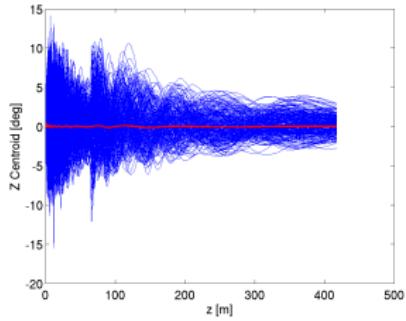


Figure: RMS Emittance Z

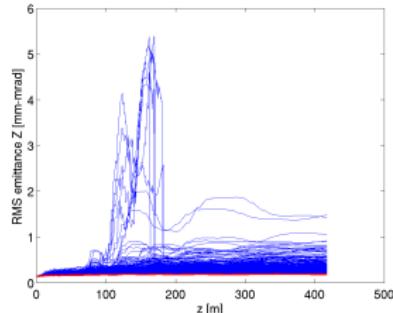
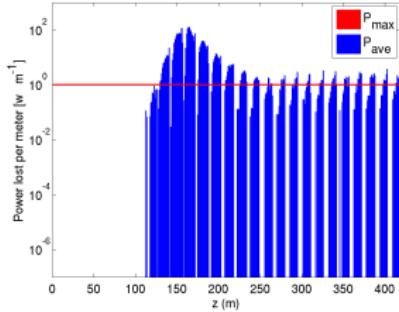


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(029) Cav. Field $\delta\phi_{dyn} = 2.0^\circ$

Figure: RMS Emittance X

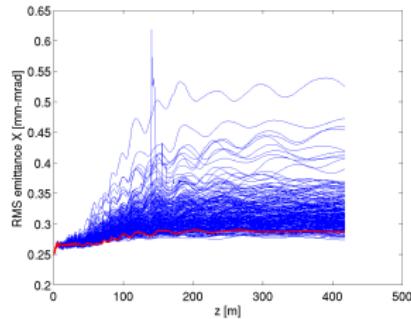


Figure: Centroid Z

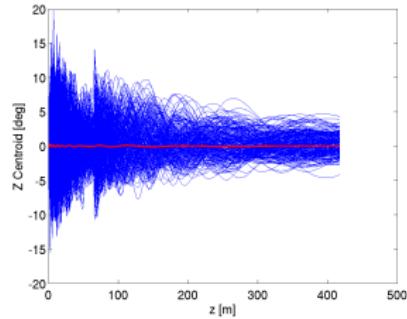


Figure: RMS Emittance Z

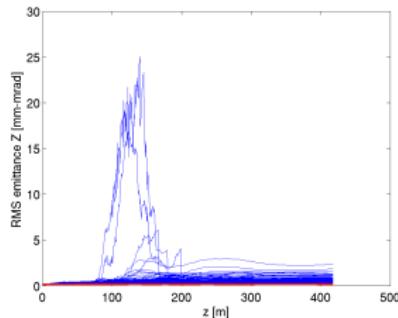
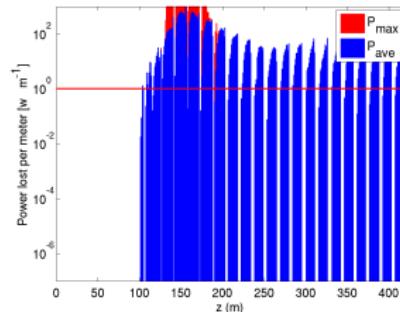


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(030) Cav. Field $\delta\phi_{dyn} = 2.5^\circ$

Figure: RMS Emittance X

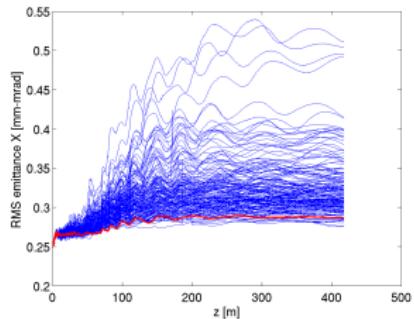


Figure: Centroid Z

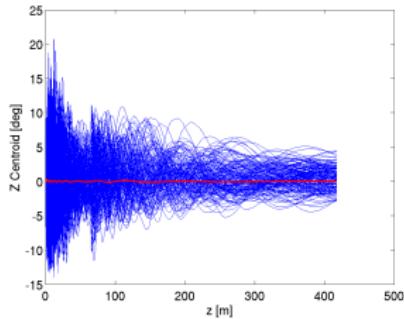


Figure: RMS Emittance Z

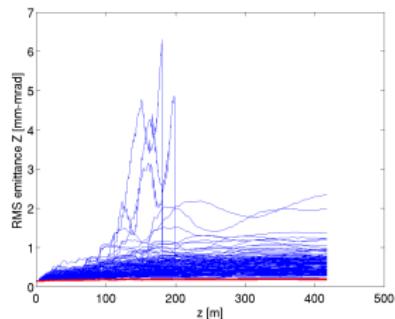
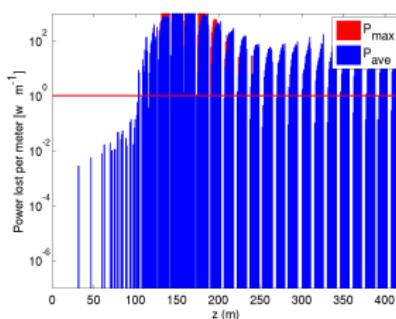


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(031) Cav. Field $\delta F_{dyn} = 0.5 \%$

Figure: RMS Emittance X

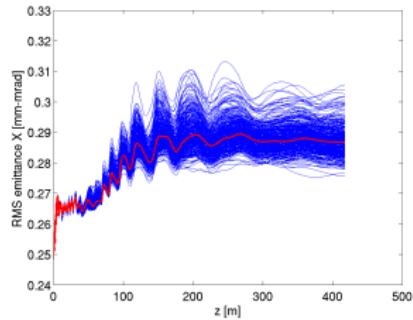


Figure: Centroid Z

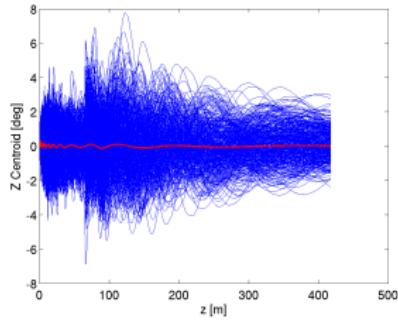


Figure: RMS Emittance Z

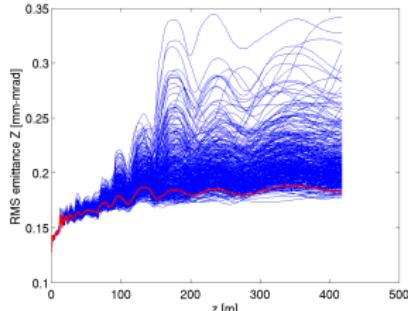
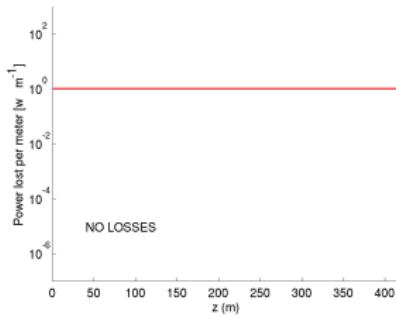


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(032) Cav. Field $\delta F_{dyn} = 1.0 \%$

Figure: RMS Emittance X

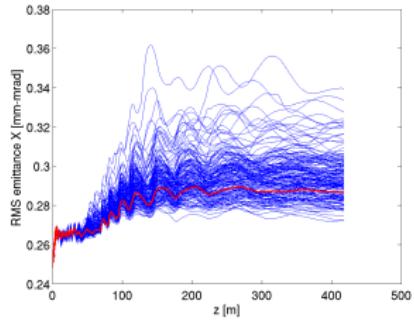


Figure: Centroid Z

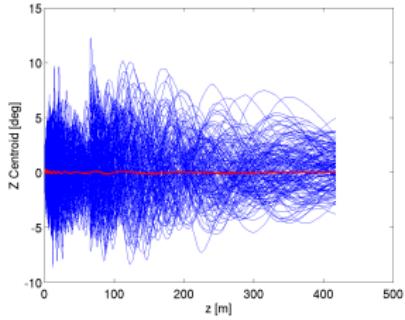


Figure: RMS Emittance Z

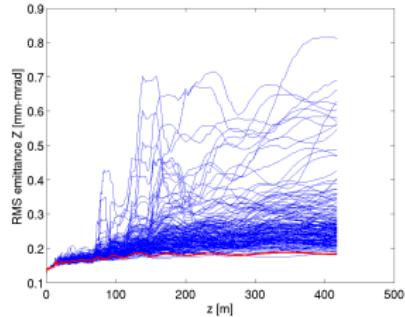
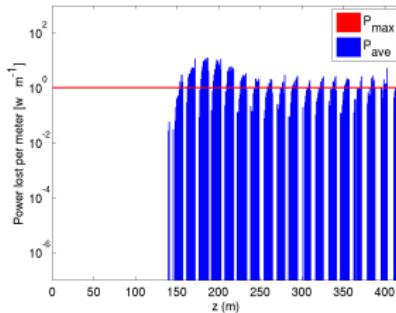


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(033) Cav. Field $\delta F_{dyn} = 1.5 \%$

Figure: RMS Emittance X

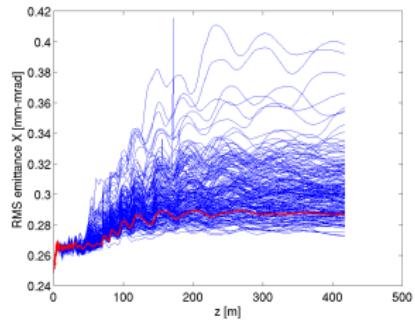


Figure: Centroid Z

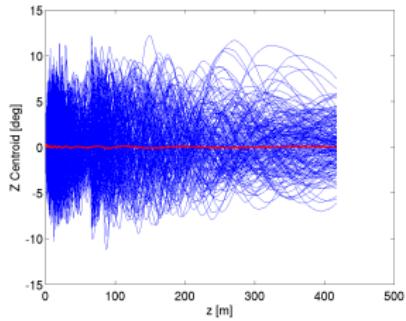


Figure: RMS Emittance Z

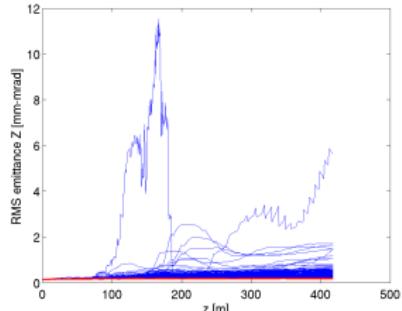
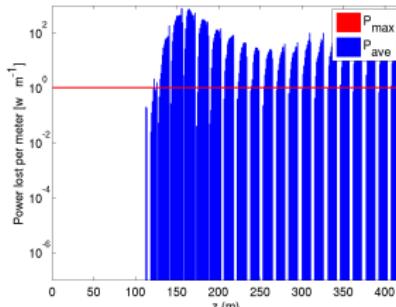


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(034) Cav. Field $\delta F_{dyn} = 2.0 \%$

Figure: RMS Emittance X

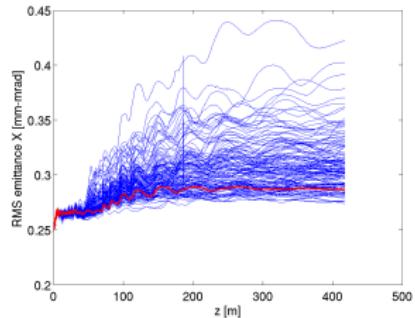


Figure: Centroid Z

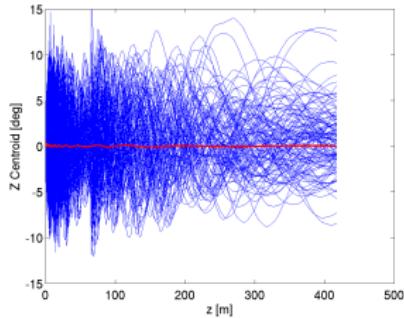


Figure: RMS Emittance Z

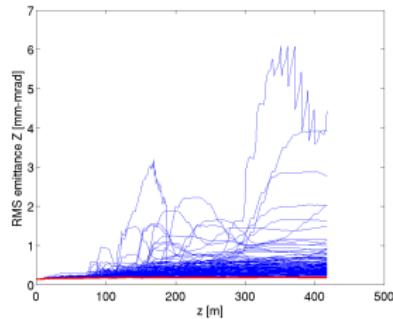
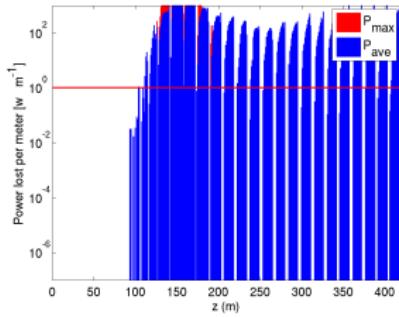


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(034) Cav. Field $\delta F_{dyn} = 2.5 \%$

Figure: RMS Emittance X

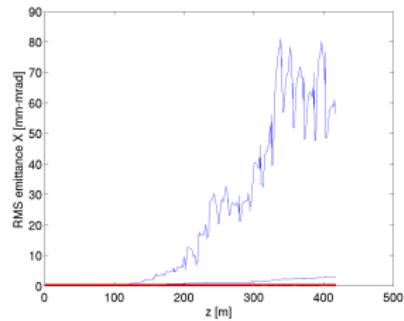


Figure: Centroid Z

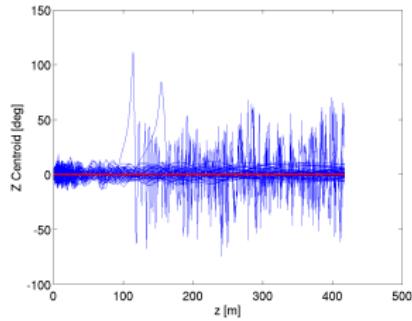


Figure: RMS Emittance Z

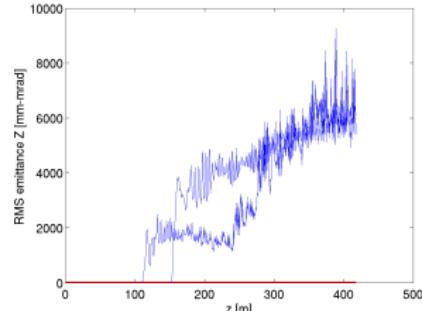
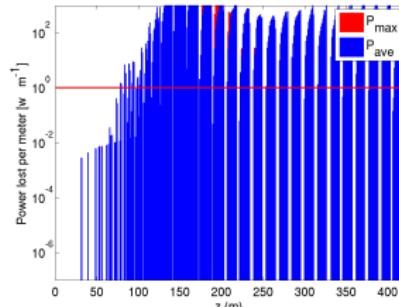


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(036) Cav. Phase and Field $\delta\phi_{dyn.} = 0.5^\circ$ & $\delta F_{dyn.} = 0.5 \%$

Figure: RMS Emittance X

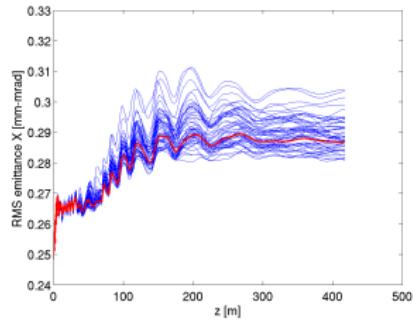


Figure: Centroid Z

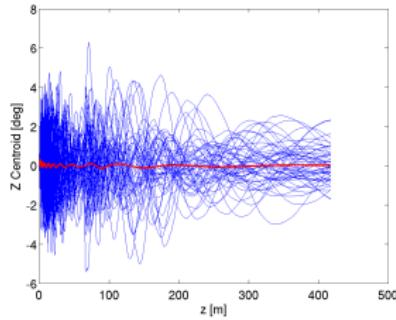


Figure: RMS Emittance Z

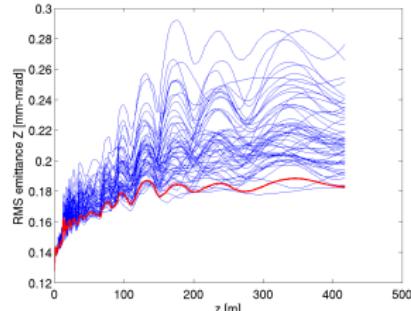
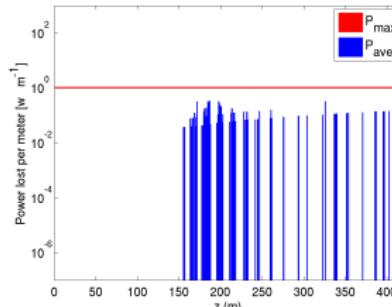


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(037) Cav. Phase and Field $\delta\phi_{dyn.} = 1.0^\circ$ & $\delta F_{dyn.} = 1.0 \%$

Figure: RMS Emittance X

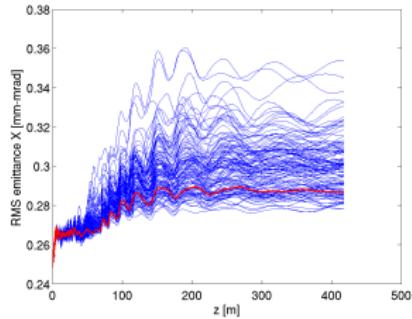


Figure: Centroid Z

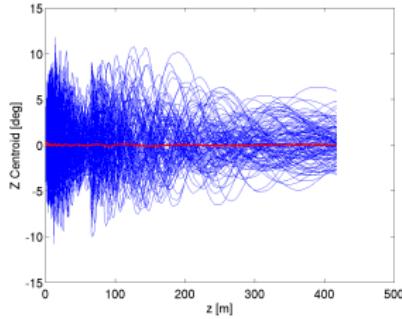


Figure: RMS Emittance Z

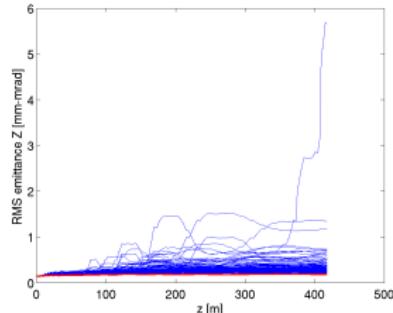
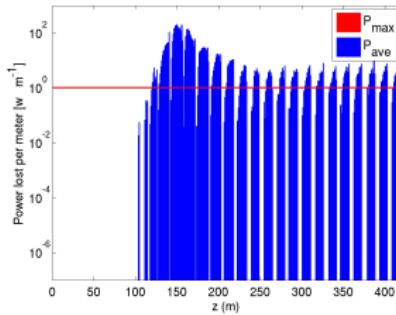


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(038) Cav. Phase and Field $\delta\phi_{dyn.} = 1.5^\circ$ & $\delta F_{dyn.} = 1.5\%$

Figure: RMS Emittance X

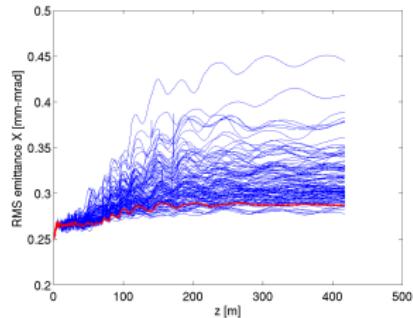


Figure: Centroid Z

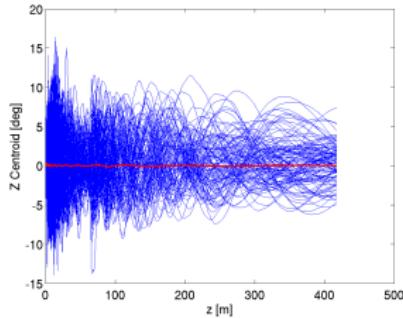


Figure: RMS Emittance Z

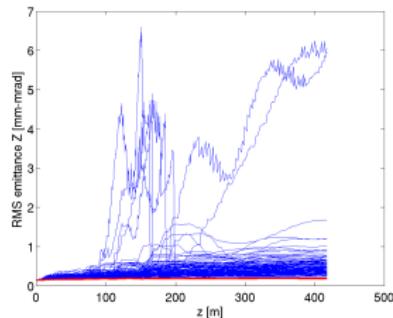
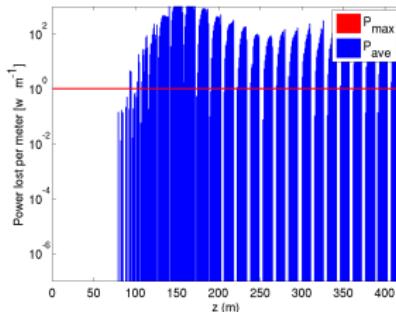


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(039) Cav. Phase and Field $\delta\phi_{dyn.} = 2.0^\circ$ & $\delta F_{dyn.} = 2.0\%$

Figure: RMS Emittance X

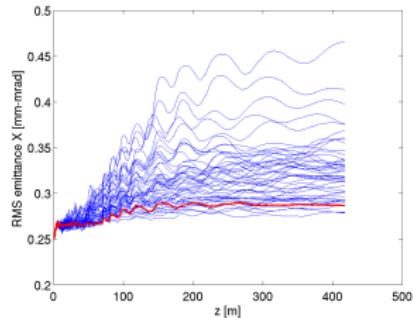


Figure: Centroid Z

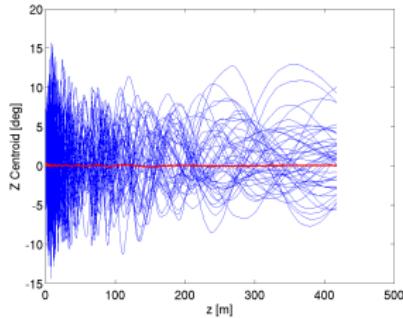


Figure: RMS Emittance Z

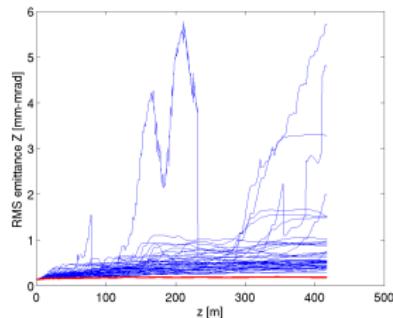
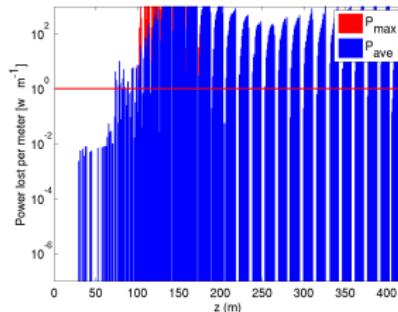


Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



(040) Cav. Phase and Field $\delta\phi_{dyn.} = 2.5^\circ$ & $\delta F_{dyn.} = 2.5\%$

Figure: RMS Emittance X

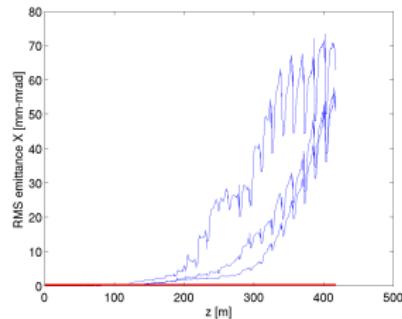


Figure: Centroid Z

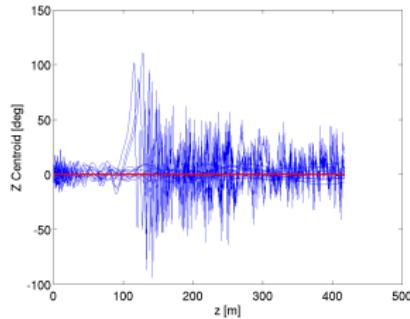


Figure: RMS Emittance Z

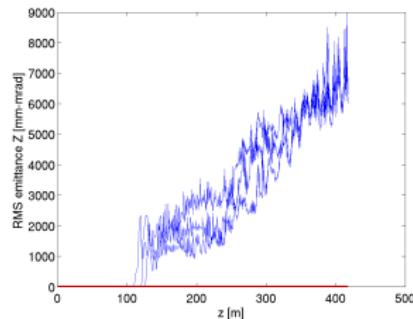
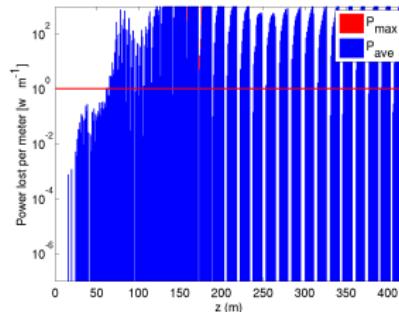


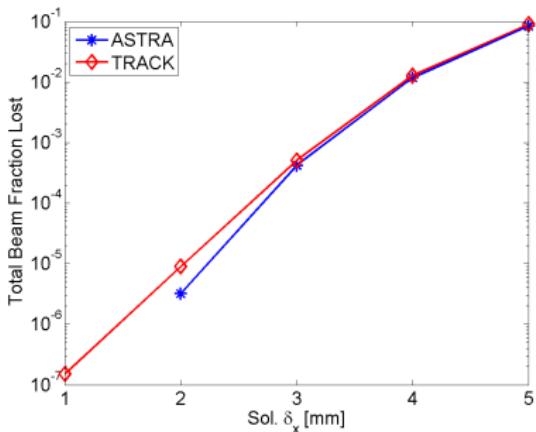
Figure: Losses [$\text{W}\cdot\text{m}^{-1}$]



Reminder TRACK /ASTRA Benchmarking / Beam Losses

Error Generation

Total beam lost at ~ 138 m
Displacement Hor. Solenoids



Total beam lost at ~ 138 m
Rotation Hor. Solenoids

